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The production of a promycelium by the aecidiospores of Caeoma nitens Burrill

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INTRODUCTION

Except in the genus *Endophyllum*, so far as known, the aecidiospores of the rusts give rise to sporophytic mycelium. Its sporophytic nature is shown by the fact that each cell contains two nuclei that have been produced by successive conjugate divisions of the two nuclei in the aecidiospore. The aecidiospores of some of the species of *Endophyllum*, however, produce a promycelium. Its cells are uninucleate and belong, therefore, to the gametophytic generation. This fact has been well established through the work of Tulasne (10), Sappin-Trouffy (8), Maire (5) and others. Hoffmann has shown that nuclear fusion occurs in the aecidiospores and that this fusion nucleus divides to form the nuclei of the sporidia. This interesting form has received considerable attention in recent years, because its life history offers suggestions regarding evolution in the rusts.

While engaged in a study of the effects of media on the germination of various spores I was surprised to find that the aecidiospores of *Caeoma nitens* taken from leaves of *Rubus frondosus* Bigel. on germination produce a promycelium in much the same way as do the aecidiospores of *Endophyllum Sempervivi* Lév. My first suspicion that this might be due to the influence of the medium upon which the spores had been placed proved groundless, for further tests showed that they germinate in exactly the same way when placed in distilled water or in tap water. The production of a promycelium by these aecidiospores seems to have escaped the observation of the numerous students of this common and widely distributed rust.

Galloway (6) figured them germinating in water and shows that the germ tube becomes more or less septate. He did not, however, observe the production of sporidia and his drawings hardly suggest the promycelial nature of the germ tube. Clinton (1) has also studied the germination of these spores and gives more than twenty figures, showing them in various stages of development, but he failed to find any trace of sporidia. He mentions having observed the spores in water cultures during two or three days and gives a detailed account of their germination. He also observed the germination of the spores on the moist surface of young blackberry leaves.

Olive (7) and Kurssanow (4) have investigated *Caeoma nitens* from the cytological standpoint. They have shown that sexual fusions occur in the base of the caeoma and that the aecidiospores typically contain two nuclei.

OBSERVATIONS

The aecidiospores used in this study of their germination were obtained from well infected leaves of *Rubus frondosus*. The leaves were collected in three different parts of Van Cortlandt Park, New York City. All of the spores germinated in the same fashion.

The cultures were made in Petri dishes containing distilled water, tap water, and agar media of various kinds. The spores were simply dusted over the surface of the medium and generally gave a high per cent of germination. The cultures were kept at room temperature (about 23° C.).

The promycelium ordinarily consists of five cells (FIG. 1, *a*), four of which bear sporidia. Stained preparations show that the stalk cell is without a nucleus and that the other four cells contain one nucleus each (FIG. 1, *b*), thus demonstrating the promycelial nature of the germ tube. Frequently the promycelium consists of only four cells and in that case each cell is capable of producing a sporidium (FIG. 1, *c*). There are also instances where the promycelium consists of less than four cells, but in such cases two or more sporidia are generally produced on the same cell. The promycelium sometimes consists of more than five cells (FIG. 1, *d*). Five or six sporidia are sometimes produced by the same promycelium, but this is a very rare case. In FIG. 1, *e* is shown a basidium with sporidia in different stages of development; it also shows one sporidium that has fallen off from its sterigma and has begun to germinate.

The sterigma arises as a pointed outgrowth from a promycelial cell. It tapers evenly and is generally slightly curved rather than straight. Its diameter at the base varies between three and five microns, while at the tip its diameter measures from one and one half to two and one half microns. It normally reaches a length of from fifteen to twenty microns, but in some cases it becomes much longer.

The sporidium, as is the rule in the rusts, is a typically kidney-shaped spore, slightly narrower at its basal than at its distal end. Maturing in a short time after the aecidiospore begins to germinate, it soon falls off from its sterigma and, on a moist surface, germinates in a few hours. Sometimes it produces a secondary sporidium, but more often it may develop a corkscrew-shaped germ tube that frequently reaches a length eight or ten times that of the sporidium. Occasionally this germ tube shows branching. The diameter of this germ tube is always much less than the diameter of the normal promycelium.

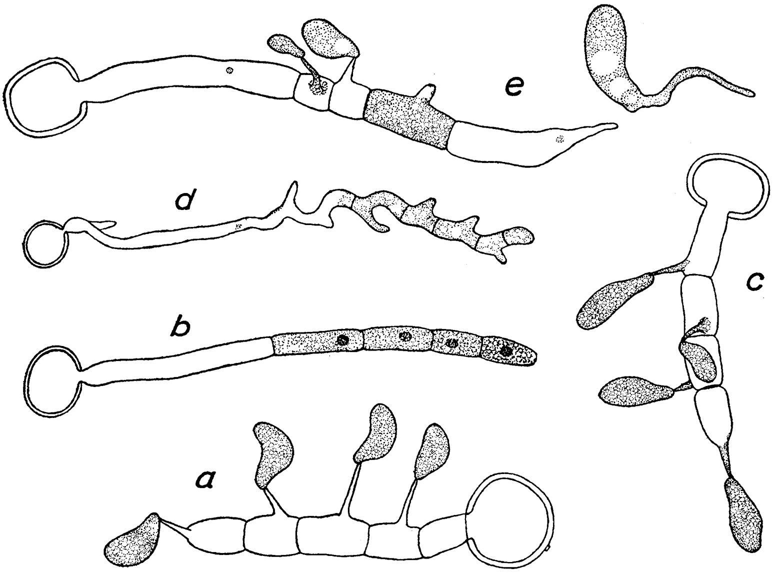

FIG. 1. *a*, Normal germinating aecidiospore, with promycelium bearing sporidia; *b*, normal uninucleated promycelium; *c*, aecidiospore giving rise to a four-celled promycelium; *d*, aecidiospore producing an abnormal promycelium; *e*, germinating aecidiospore with promycelium bearing sporidia in different stages of development.

Although there is considerable variation in the length and shape of the promycelium when grown on various media, under fairly similar conditions it is rather constant both in size and in shape. Generally it reaches a length of three or four times the diameter of the spore, but sometimes it becomes much longer than this. The average diameter of the spore, based on a measurement of twenty-five spores taken at random, is twenty-one microns. The average length of the mature promycelium, based on the same number of measurements, is seventy-eight microns.

DISCUSSION

Tranzschel (9) and Clinton (2) both claim to have established by infection experiments that *Puccinia Peckiana* Howe is the teleutostage of *Caeoma nitens*. Tranzschel removed three healthy blackberry plants from the park of the St. Petersburg Forestry Institute. One of these plants he grew under a bell jar in the laboratory of the Institute; the other two plants were placed in a garden. The three plants were inoculated with spores of *Caeoma nitens*. Later in the season all of the three plants became infected with *Puccinia Peckiana*. Tranzschel had no control plants in his experiment and he makes no mention of having observed the plants in the park of the St. Petersburg Forestry Institute at the time his plants showed infection with the *Puccinia*.

Clinton transplanted blackberry plants from the forest to his greenhouse. He inoculated two of these with the aecidiospores of *Caeoma nitens* taken from infected blackberry plants. In a little less than two months both of these plants showed infection with *Puccinia Peckiana*, while several other blackberry plants that had been used as checks showed no infection. It is worth noting that three raspberry plants which he inoculated with spores of *Caeoma nitens* taken from infected raspberry plants, failed to become infected. All plants used had been free from both the *Caeoma* and the *Puccinia* during the previous summer.

It is hardly to be expected that the change from sporophyte to gametophyte should occur in two different places in the life history of the same rust, but further experiments are needed in order to settle this point.

The production of a promycelium by the aecidiospores of

Caeoma nitens suggests that it is a short-cycled rust in no way connected with *Puccinia Peckiana* and in its life history quite comparable to *Endophyllum Sempervivi.* The perennial mycelium lives over winter in the tissues of the host. Cell fusions at the base of the chains of aecidiospores produce sporophytic cells from which the aecidiospores arise by conjugate division of the two cells that fuse. This gives binucleated aecidiospores and intercalary cells. The fact that the aecidiospores germinate in a promycelium suggests that here, as in *Endophyllum*, nuclear fusion takes place in the aecidiospore and we may expect that the sporidia produced by the promycelium reinfect the host and produce a mycelium with uninucleated cells, thus completing the life cycle.

If, on the other hand, *Puccinia Peckiana* is a stage in the life history of this fungus, the problem is not so simple and no similar case is known among the rusts.

As was pointed out in the introduction, the fact that sexual fusions occur previous to the production of aecidiospores is well established. The above described germination of these spores makes clear another stage in the life history of this fungus, and raises a number of interesting questions regarding its position among the rusts. I shall test during the coming summer the evidence regarding the connection supposed to exist between *Caeoma nitens* and *Puccinia Peckiana,* and shall also undertake a cytological study of both of these forms. The wide distribution and economic importance of *Caeoma nitens*, its abundant production of spores and the ease with which they may be germinated and studied makes it a favorable object for class use. It is, therefore, highly important that all stages in its life history should be thoroughly understood.

SUMMARY

1. The aecidiospores of *Caeoma nitens* on germination regularly produce a promycelium.

2. This promycelium normally consists of five cells. The stalk cell contains no nucleus, but the other four cells contain one nucleus each.

3. Each uninucleated cell bears a sporidium on a sterigma.

4. These sporidia germinate immediately by producing either a secondary sporidium or a germ tube.

5. The production of a promycelium by these aecidiospores suggests that *Caeoma nitens* is a short-cycled rust and casts doubt on the connection supposed to exist between this fungus and *Puccinia Peckiana.*

6. *Caeoma nitens* is the only rust of the caeoma type, having aecidiospores that are known to produce a promycelium. The other rusts having aecidiospores that are known to function as teleutospores, belong to the one genus *Endophyllum.*

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